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(54) **DIFFERENTIAL GEAR**

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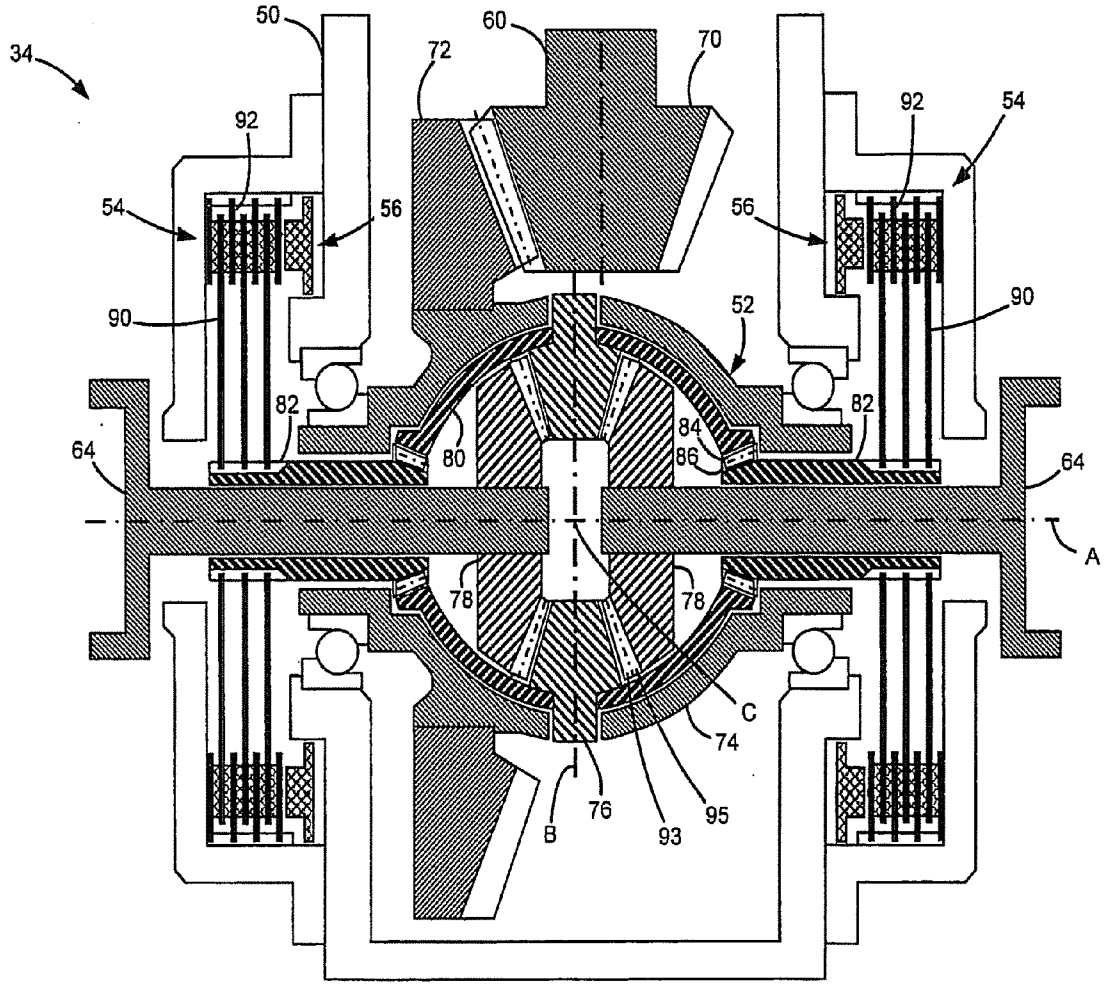
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(57) **ABSTRACT**

A transmission has a rotatable differential cage (**74**) and two output shafts (**64**). In order to distribute a torque between the output shafts (**64**), at least one balancing wheel (**76**) is rotatably mounted on the differential cage (**74**), which balancing wheel (**76**) is drive-coupled to a respective drive wheel (**78**) of the output shafts (**64**). The gearing also has at least one concavely curved coupling wheel (**80**) which is drive-coupled firstly to at least one of the drive wheels (**78**) and secondly to at least one hollow shaft (**82**). The hollow shaft (**82**) surrounds one of the output shafts (**64**). The hollow shaft (**82**) can be braked or driven relative to a part of the gearing.



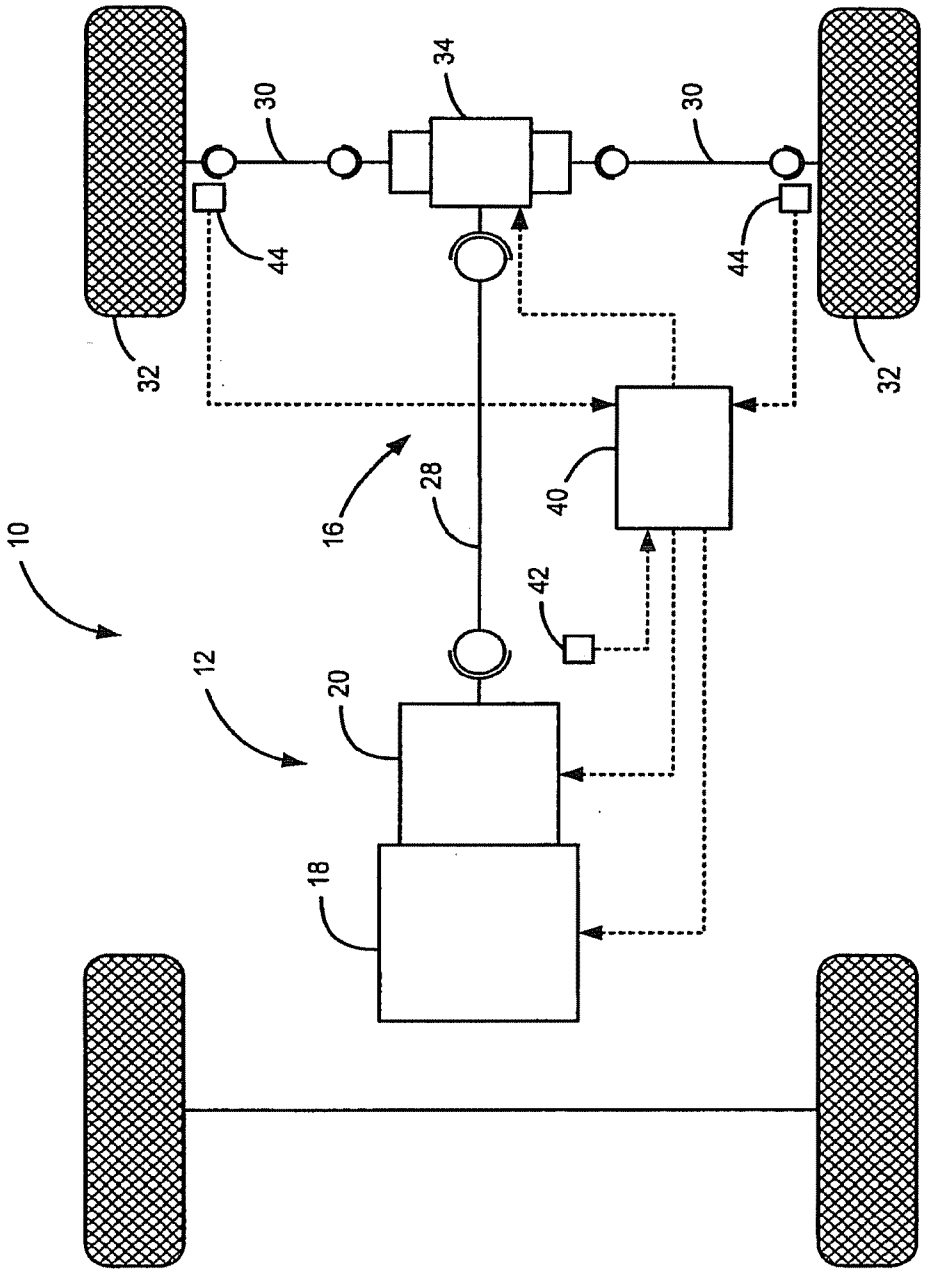


Fig. 1

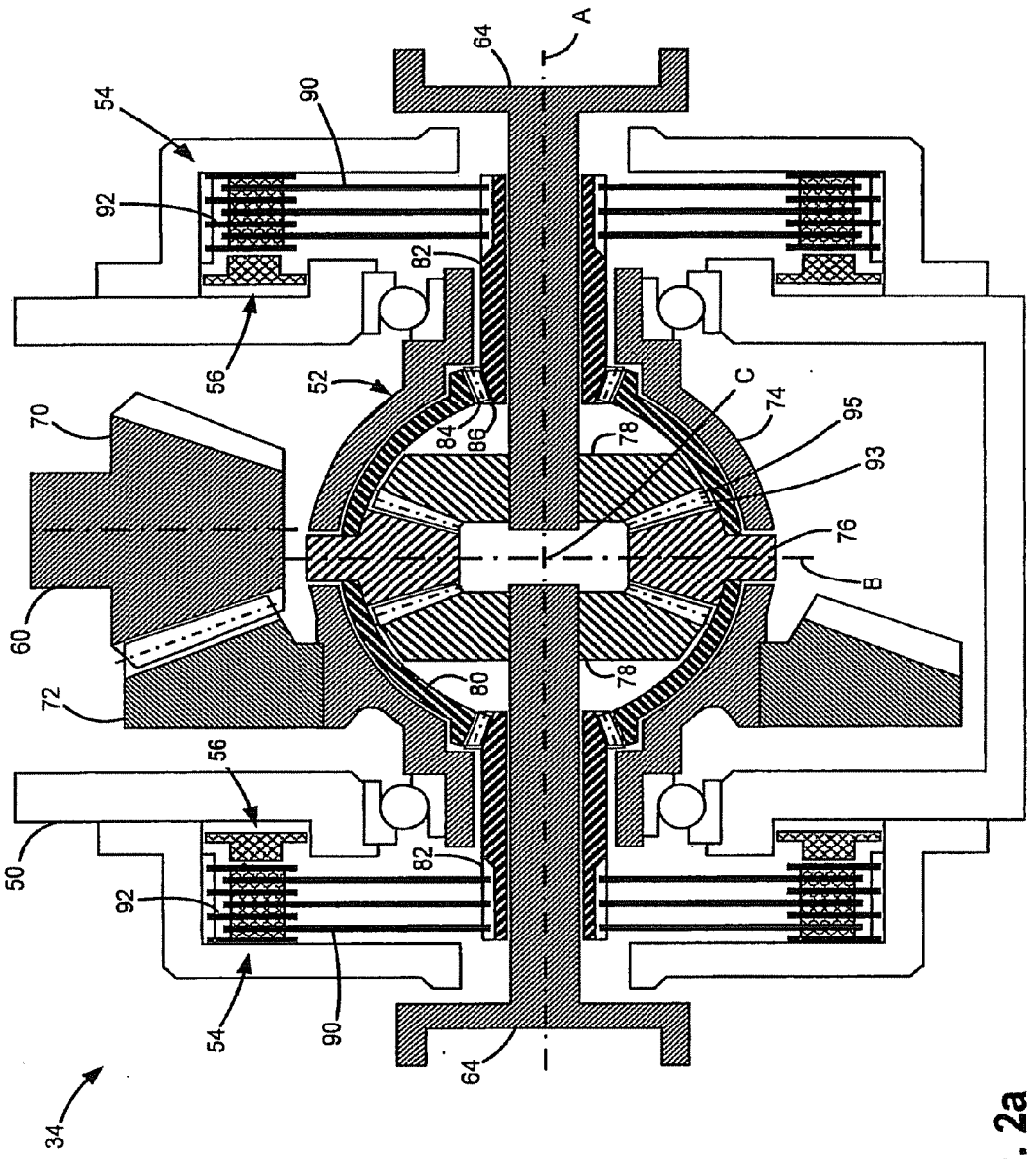

64
A
54
90
92
82
56
52
C
74
95
70
84
86
78
93
76
B
60
72
80
78
56
50
82
92
54
90
64
34

Fig. 2a

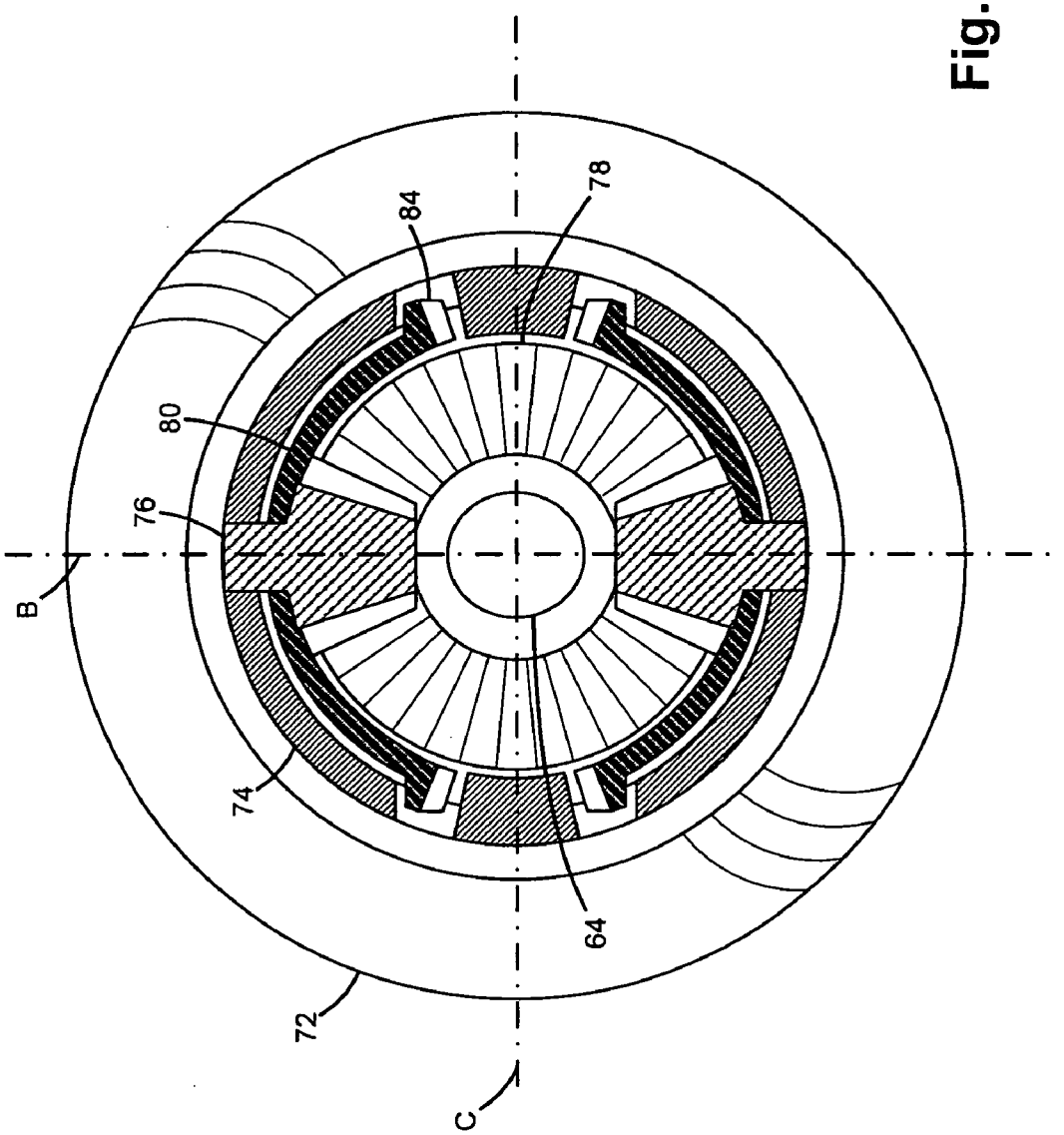


Fig. 2b

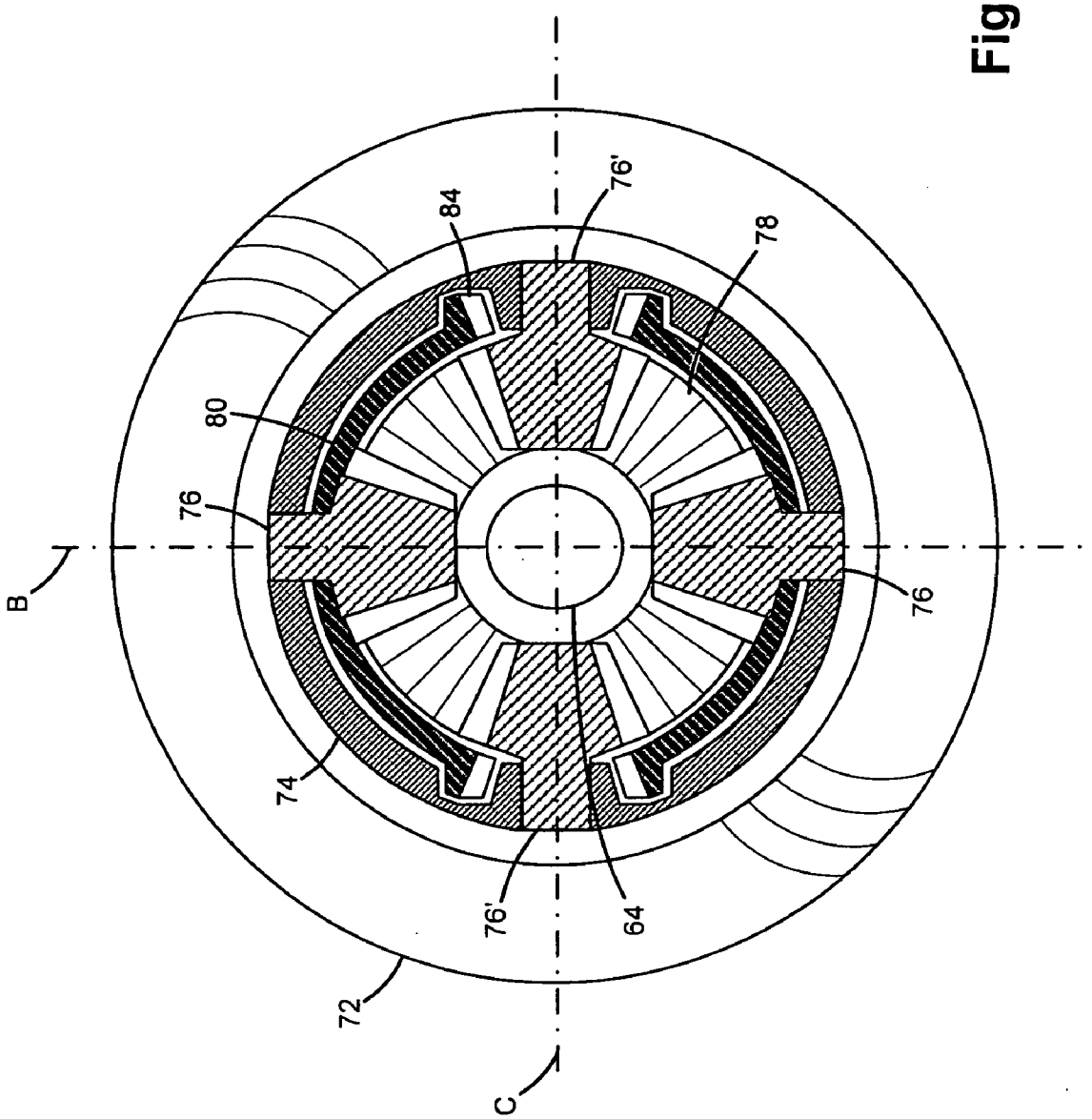


Fig. 2c

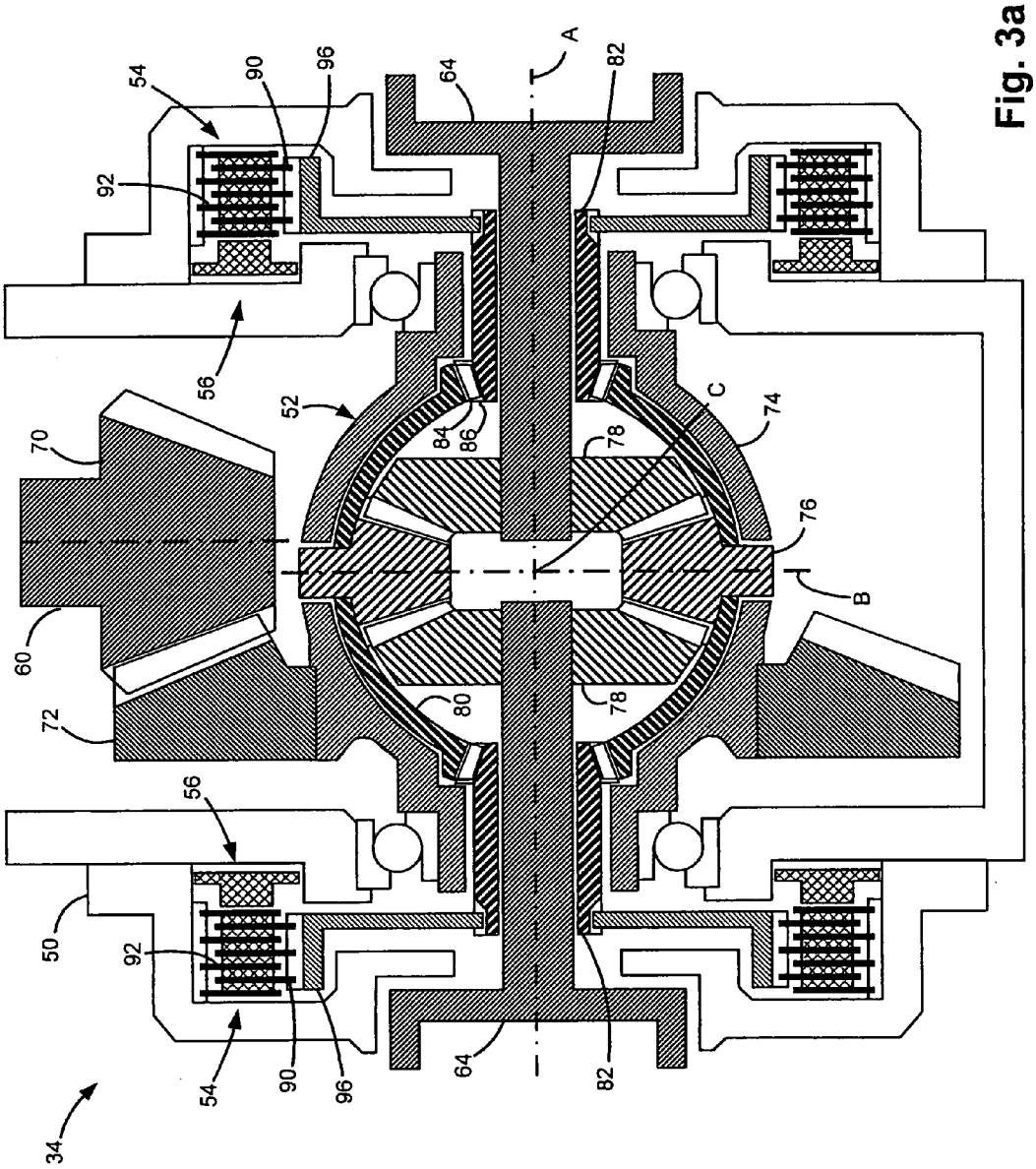


Fig. 3a

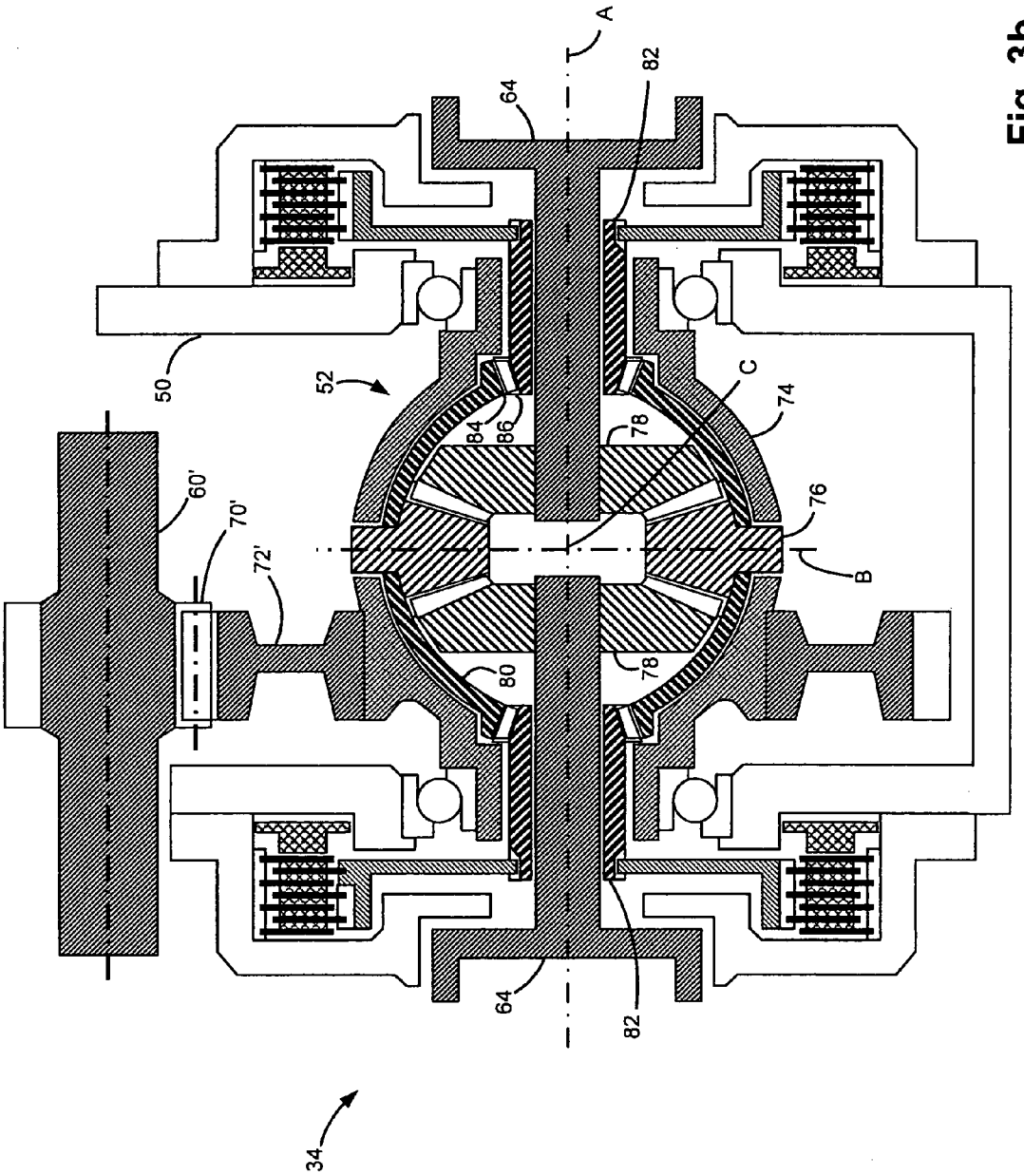


Fig. 3b

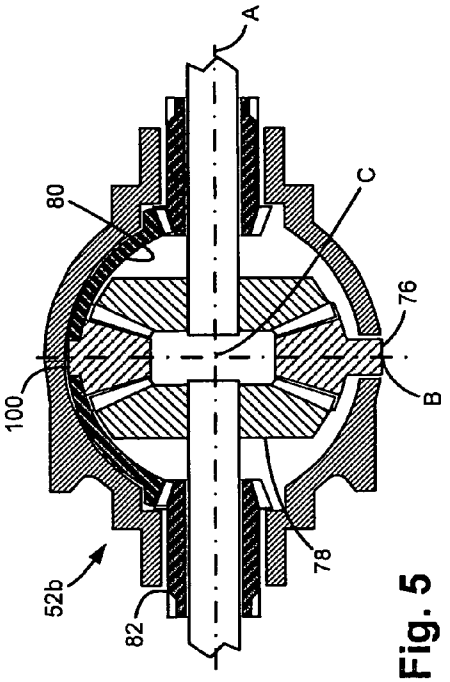


Fig. 5

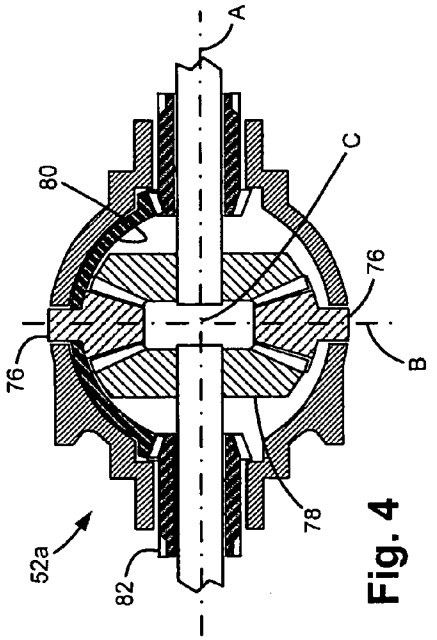


Fig. 4

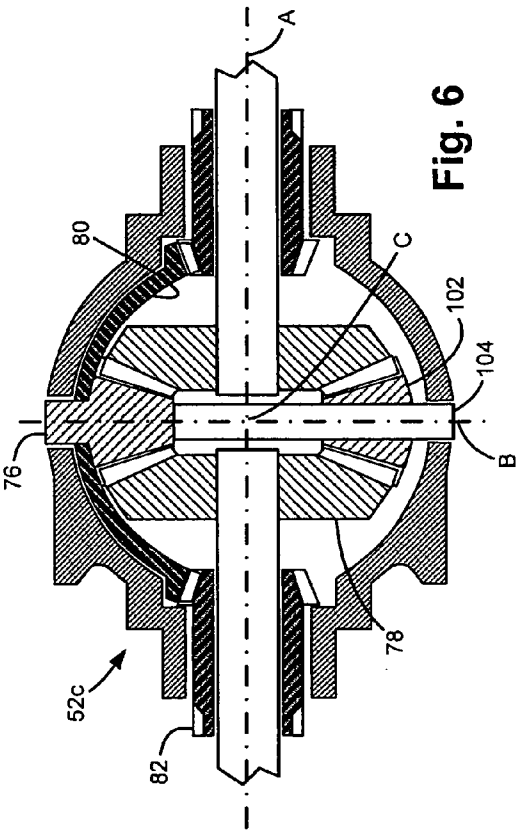


Fig. 6

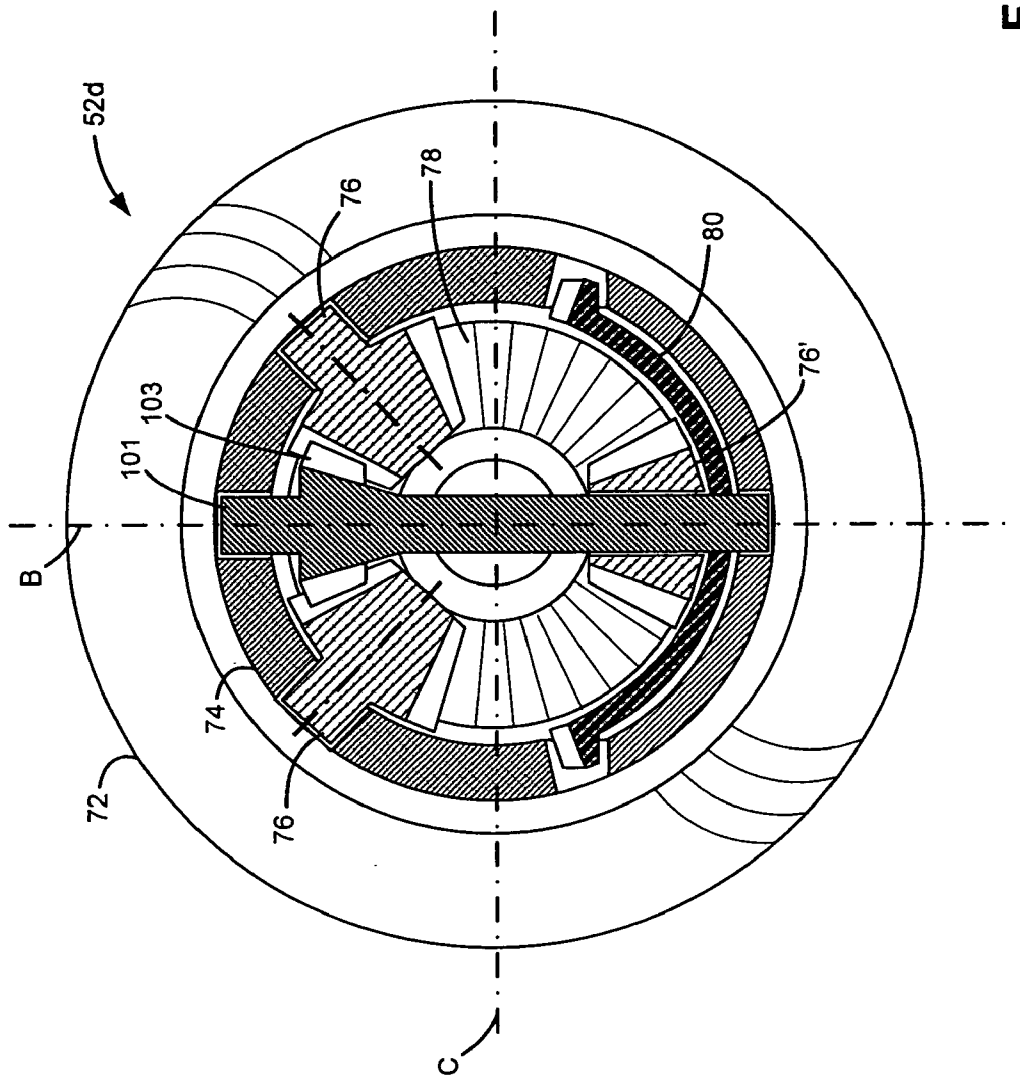
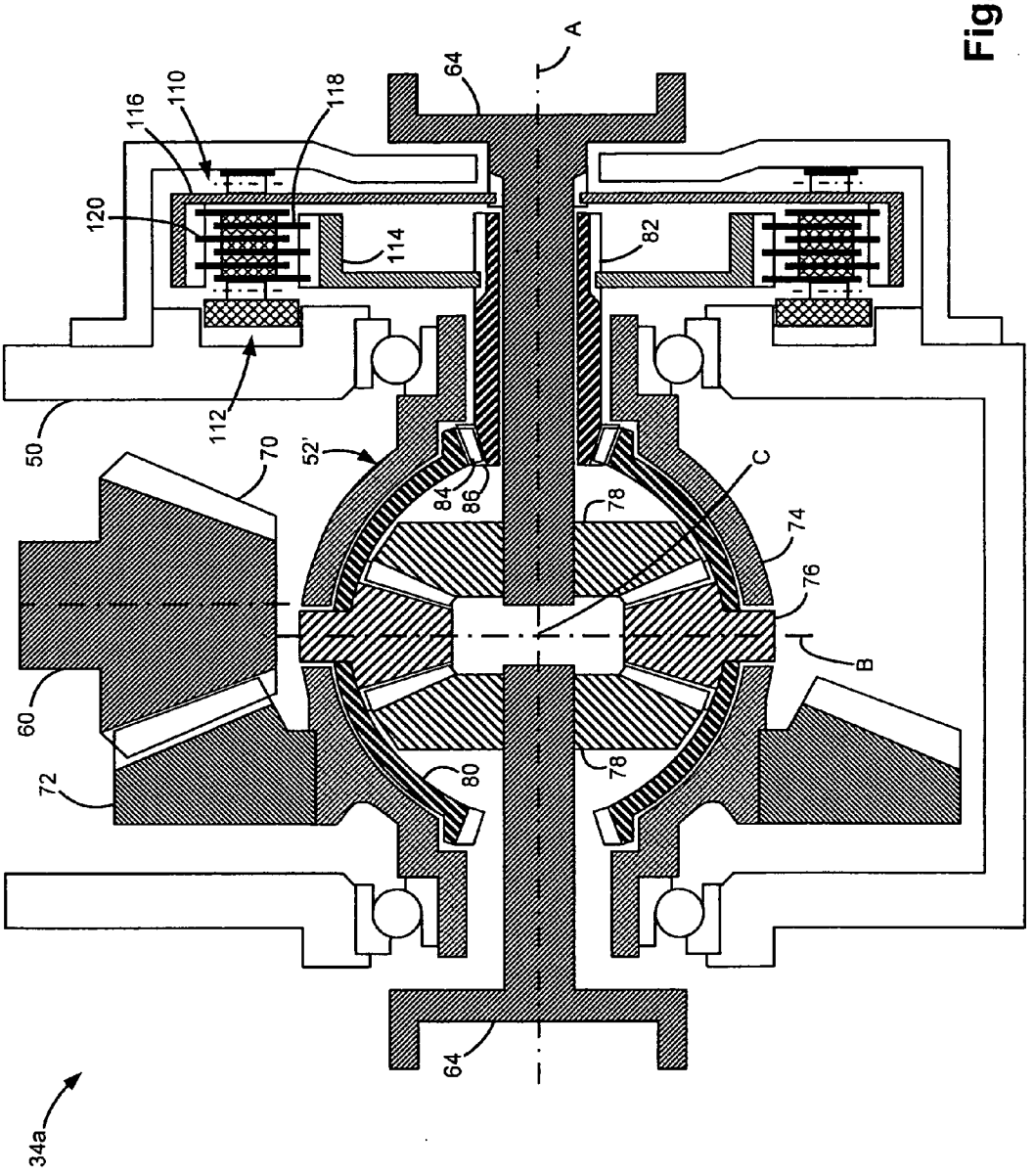


Fig. 7

Fig. 8


A
64
116
110
118
120
114
82
112
50
52'
70
84
86
78
C
74
76
B
60
72
80
78
64
34a

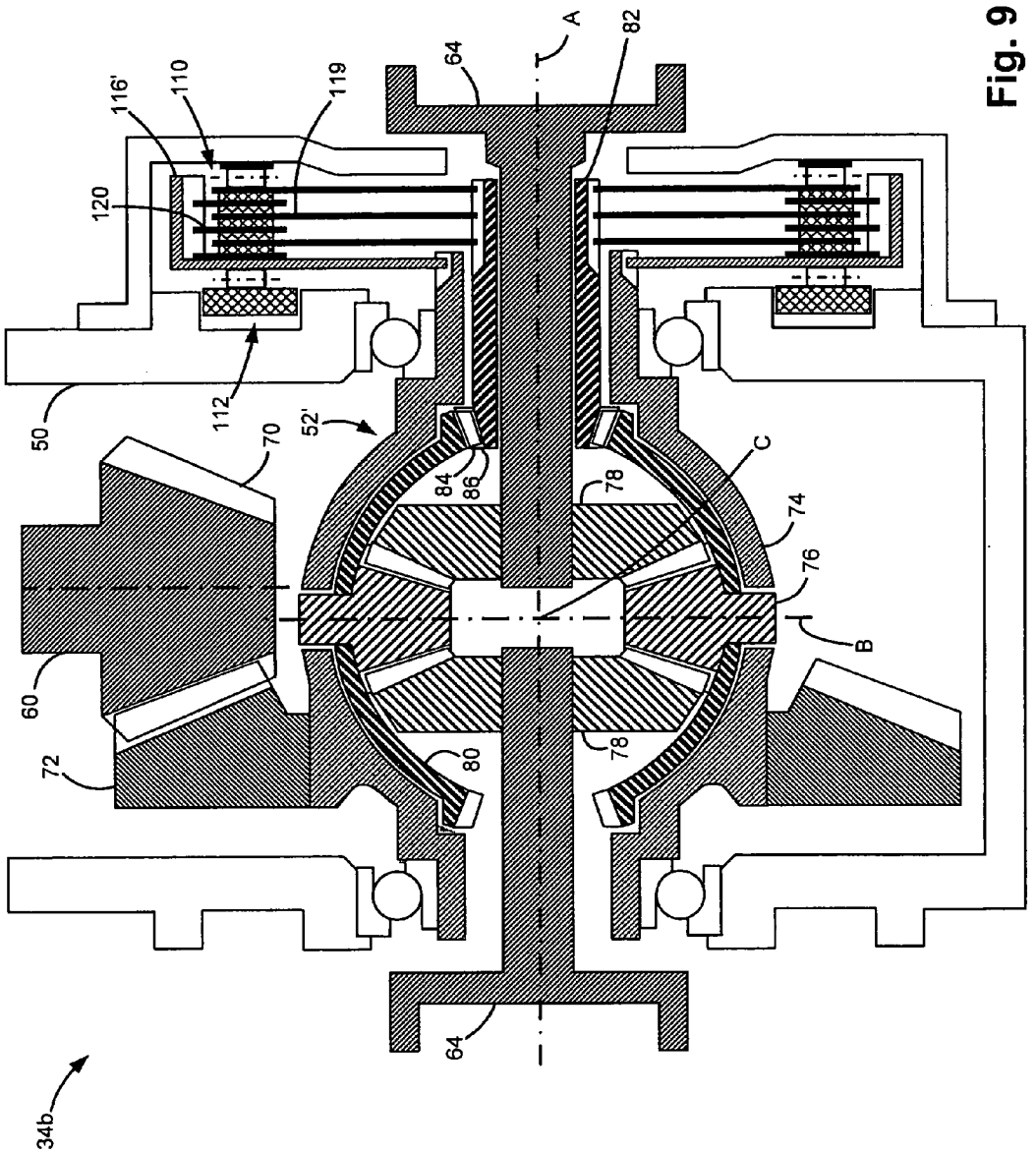

116'
110
119
64
A
82
120
50
112
52'
70
84
86
78
C
74
76
B
60
72
80
78
64
34b

Fig. 9

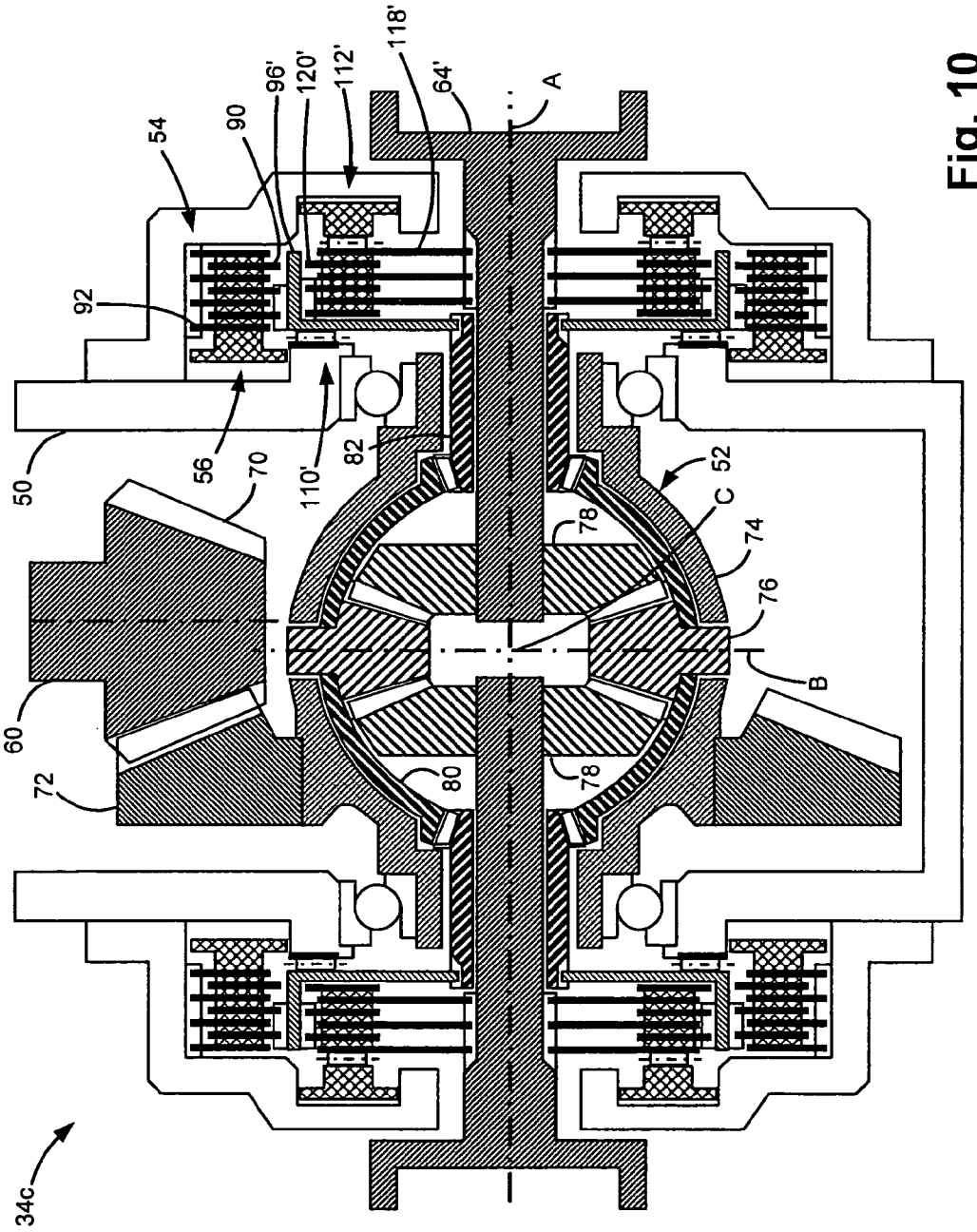

118'
96'
120'
112'
64'
A
54
90
92
50
56
70
110'
82
52
C
78
74
76
B
60
72
80
78
34c

Fig. 10

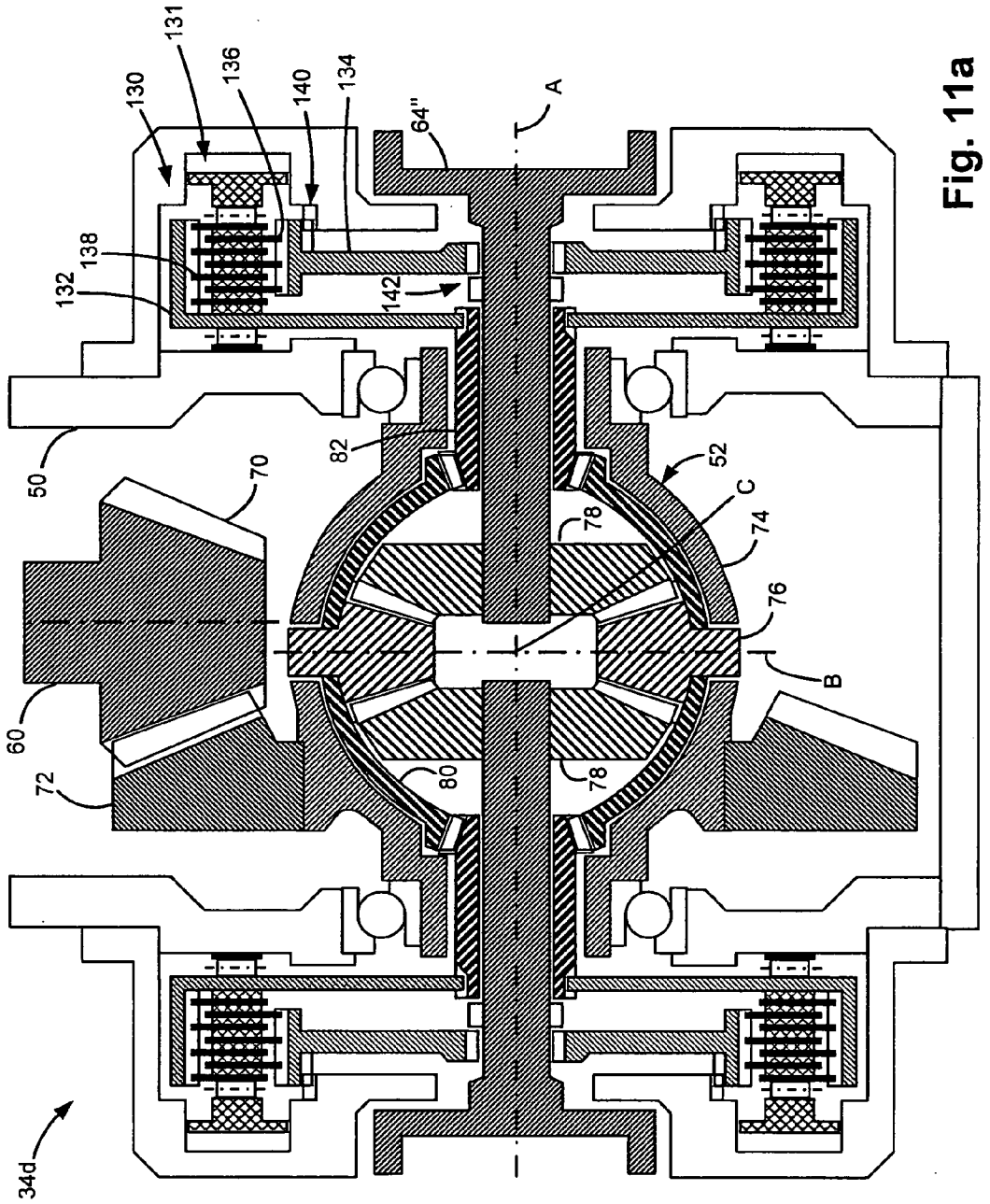

131
130
136
140
134
64"
A
138
132
142
50
82
52
70
C
78
74
76
B
60
72
80
78
34d

Fig. 11a

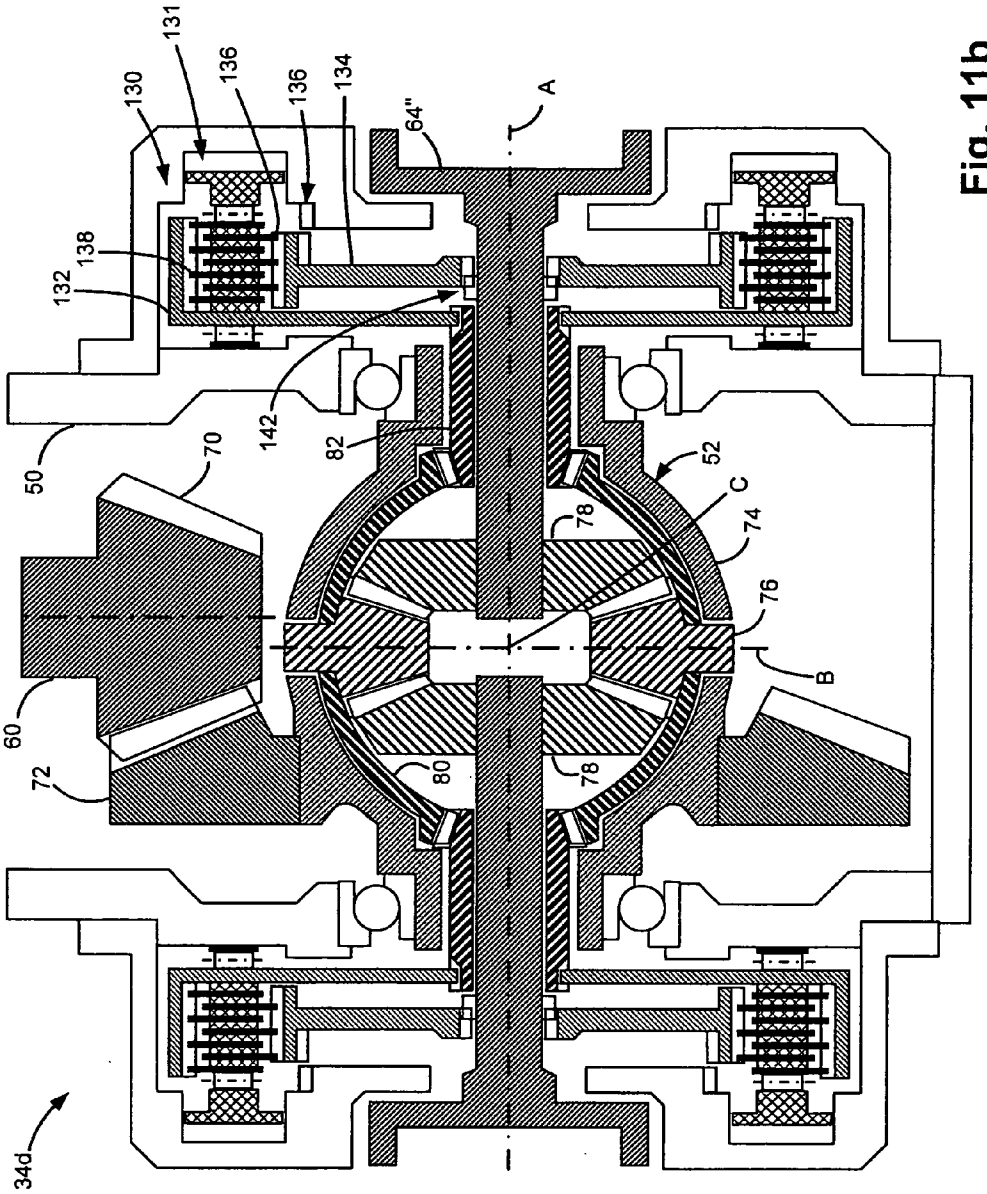

131
130
136
136
134
64"
A
138
132
142
82
50
70
52
C
78
74
76
B
60
72
80
78
34d

Fig. 11b

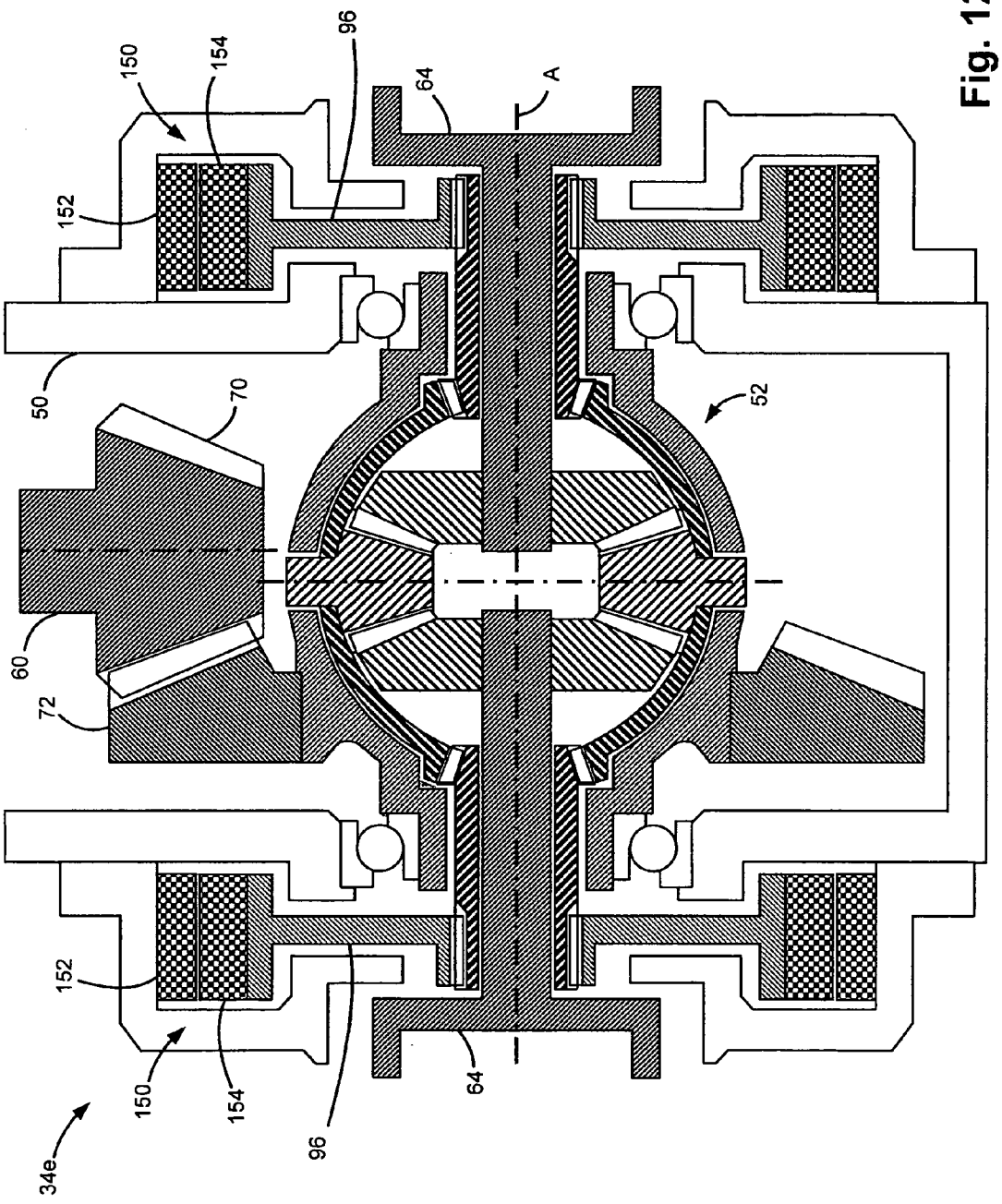


Fig. 12

DIFFERENTIAL GEAR

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a 371 U.S. National Stage of International Application No. PCT/EP2007/009374. filed Oct. 29, 2007. This application claims the benefit of German Patent Application No. DE 10 2006 058 835.5, filed Dec. 13, 2006. The disclosures of the above applications are incorporated herein by reference.

FIELD

[0002] The present invention relates to a transmission for a motor vehicle having a rotatable differential cage and two output shafts, wherein at least one balancing gear which is drive-operatively coupled to a respective driven gear of the output shafts is rotatably journaled at the differential cage for the distribution of a torque between the output shafts.

BACKGROUND

[0003] This section provides background information related to the present disclosure which is not necessarily prior art.

[0004] So-called "active yaw" systems or "torque vectoring" (TV) systems are known for modern powertrains (e.g. all-wheel powertrains). The yaw speed of the vehicle is actively controlled by a TV system, with the driving torques being able to be distributed to the wheels asymmetrically. More torque can thereby be directed, for example, to the wheel at the outside of the corner so that an oversteer behavior can be set under normal driving conditions.

[0005] To be able to suppress the generally desired balance of speed differences in specific driving situations, differential gears are also known with a selectively activatable differential lock.

[0006] Conventional differential gears include a differential which balances the speed differences of the output shafts. A pure differential cannot actively influence existing speed differences The differential gear in particular requires a plurality of additional components to transmit an increased driving torque to a specific wheel of the vehicle or to enable a differential locking operation.

SUMMARY

[0007] It is an object of the invention to provide a transmission which can be used in a TV system and/or in a differential locking operation with a simple and compact structure.

[0008] This object is satisfied by a transmission having a rotatable differential cage, two output shafts each having a driven gear, and at least one balancing gear drive-operatively couple to the driven gears and rotatably journaled at the differential cage. The transmission furthermore has at least one concavely arched coupling gear which is drive-operatively coupled, on the one hand, to at least one of the driven gears of the output shafts and, on the other hand, to at least one hollow shaft gear, with the hollow shaft gear surrounding one of the output shafts and with the hollow shaft gear being able to be braked and/or driven relative to a part of the transmission.

[0009] The concavely arched coupling gear enables a rotationally operative coupling of one of the driven gears or of both driven gears of the output shafts to the respective hollow shaft gear, with a braking device or a drive device by means of which the hollow shaft gear can, for example, be braked or accelerated with respect to a housing of the transmission or with respect to the associated output shaft or of the differential cage being associated with the respective hollow shaft gear. A specific speed ratio can hereby be set between the output shafts. Particularly favorable transmission ratios can be realized in this respect by the concavely arched shape of the coupling gear.

[0010] The concavely arched coupling gear in conjunction with the balancing gear thus forms a compact superimposition unit which easily has room within the construction space of a given differential unit. In addition, the differential unit only requires a few parts to provide a TV operation or a differential locking operation. The differential unit is thus smaller, lighter, simpler and above all cheaper than conventional differential units which enable a TV operation or a differential locking operation. Further advantages are low rotating masses and a more favorable power flow.

[0011] It is not absolutely necessary for the named drive-operative coupling of the coupling gear to the driven gears of the output shafts that a coupling gear toothed arrangement is directly in engagement with a respective toothed arrangement of the driven gears. Instead, it is possible that the coupling gear is rotationally fixedly connected to the at least one balancing gear or to a connection gear which in turn meshes with the driven gears of the output shafts or that the coupling gear is rotationally fixedly connected to an idler gear which is in turn coupled to the driven gears of the output shafts via a balancing gear. A direct engagement is preferably provided between the coupling gear and the at least one hollow shaft.

[0012] In a preferred embodiment, the transmission furthermore includes a second balancing gear which is drive-operatively coupled to the driven gears of the output shafts and a second concavely arched coupling gear which is drive-operatively coupled, on the one hand, to the second balancing gear and, on the other hand, to the at least one hollow shaft gear. The transmitting torque is thus distributed between a plurality of coupling gears as well as a plurality of balancing gear, whereby the gears, toothed arrangements and bearings can be made smaller and whereby symmetrical, balanced forces are adopted at the hollow shaft gear or hollow shaft gears.

[0013] In a further preferred embodiment, the coupling gear or coupling gears are rotatably journaled at the differential cage. The balancing gear thus acts as a conventional differential balancing gear which drives the output shafts upon rotation of the differential unit. No additional balancing gears are required in this manner.

[0014] In a further preferred embodiment, the number of teeth of a toothed arrangement of the coupling gear or of the plurality of coupling gears is larger than the number of teeth of an associated toothed arrangement of the respective hollow shaft gear. In a similar manner, the number of teeth of a toothed arrangement of the balancing gear or of the plurality of balancing gears is preferably smaller than the number of teeth of an associated toothed arrangement of the respective driven gear of the output shafts. Advantageous transmission ratios are thereby achieved, with a transmission of the superimposition unit of less than 15% being achievable.

[0015] In a further preferred embodiment, the coupling gear is rotationally fixedly connected to an idler gear via an intermediate shaft, with the idler gear meshing with at least one balancing gear which in turn meshes with the driven

gears. The transmission ratios of less than 15%, for example, can thus be achieved because the idler gear can be very small.

[0016] In accordance with a further advantageous embodiment, the mutually meshing toothed arrangements of coupling gear and hollow shaft gear and/or the mutually meshing toothed arrangements of balancing gears, optionally idler gears and driven gears are not made—as usual—as bevel gear toothed arrangements, but rather as crown gear pairs. This permits an even more compact construction, extended transmission ranges and the elimination of axial forces. Crown gear pairs are characterized in that a crown gear meshes with a spur gear. In such a construction, the hollow shaft toothed arrangement is, for example, made as a spur gearing and the coupling gear, for example, as a crown gear. Alternatively or additionally, the balancing gears and/or idler gears are made as spur gears and the driven gears as crown gears.

[0017] A powertrain of a motor vehicle includes a transmission in accordance with the invention. The transmission can be made for the torque transfer along a longitudinal axis of the powertrain. Alternatively or additionally, such a transmission can be made for the torque transfer along one or more transverse axes of the powertrain.

[0018] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0019] The drawings described herein are for illustrative purposes only of the selected embodiments and not all possible implementations have been described such that the drawings are not intended to limit the scope of the present disclosure.

[0020] FIG. **1** is a schematic representation of a motor vehicle powertrain equipped with a transmission in accordance with the invention;

[0021] FIG. **2***a* is a sectional representation of a first embodiment of a transmission with a TV operation;

[0022] FIG. **2***b* is a sectional side representation along a central symmetry plane of a differential unit associated with the transmission in accordance with FIG. **2***a* containing the axis B;

[0023] FIG. **2***c* is a sectional side representation corresponding to the representation in accordance with FIG. **2***b* of an alternative embodiment of the differential unit;

[0024] FIG. **3***a* is a sectional representation of a second embodiment of a transmission with a TV operation;

[0025] FIG. **3***b* is a sectional representation of the embodiment in accordance with FIG. **3***a* configured for use in a front axle TV operation;

[0026] FIG. **4** is a sectional representation of a first embodiment of a differential unit applicable for use with a transmission of the present disclosure;

[0027] FIG. **5** is a sectional representation of a second embodiment of a differential unit applicable for use with a transmission of the present disclosure;

[0028] FIG. **6** is a sectional representation of a third embodiment of a differential unit applicable for use with a transmission of the present disclosure;

[0029] FIG. **7** is a sectional side representation of a fourth embodiment of a differential unit applicable for use with a transmission of the present disclosure;

[0030] FIG. **8** is a sectional representation of a third embodiment of a transmission having a differential locking operation;

[0031] FIG. **9** is a sectional representation of an alternative example of the transmission embodiment in accordance with FIG. **8**;

[0032] FIG. **10** is a sectional representation of a fourth embodiment of a transmission with a differential locking operation and a TV operation;

[0033] FIG. **11***a* is a sectional representation of a simplified embodiment of the transmission in accordance with FIG. **10** which is switched into TV operation;

[0034] FIG. **11***b* is a sectional representation of the transmission in accordance with FIG. **11***a* which is switched into the differential locking operation; and

[0035] FIG. **12** is a sectional representation of a fifth embodiment of a transmission with electric motors or electric generators.

[0036] In FIG. **1**, a schematic representation of an exemplary vehicle powertrain **10** is shown which includes a drive **12** which includes a power transmission path **16**, a motor **18** and a shift transmission **20**. The power transmission path **16** includes a Cardan shaft **28** which is driven by the shift transmission **20**, a pair of half-shafts **30** connected to a pair of wheels **32**, and a transmission, hereinafter referred to as an axle drive **34**, which is operative to transmit a driving torque from the Cardan shaft **28** to one or both half-shafts **30**. Although a vehicle powertrain with rear wheel drive is shown by way of example here, the invention can naturally also be used in a vehicle powertrain with front wheel drive or with all-wheel drive.

[0037] A control unit **40** controls the operation of the axle drive **34** on the basis of a plurality of vehicle parameters to enable a so-called "torque vectoring" (TV) operation and/or a differential locking operation. The control unit **40** is electronically connected to at least one sensor—preferably to a plurality of sensors. Example sensors include a yaw rate sensor **42**, wheel speed sensors **44** and/or a steering angle sensor (not shown). Other sensors include lateral acceleration sensors and longitudinal acceleration sensors (not shown). The sensors detect a plurality of operating states, e.g. the yaw rate of the vehicle and the speed of each wheel **32**. The control unit **40** processes the signal or the signals and generates an axle drive control signal, with at least one actuator being controlled on the basis of the axle drive control signal to actively influence the transfer of the driving torque to the wheels **32**.

[0038] Although the axle drive **34** in accordance with FIG. **1** is integrated into a rear axle of the vehicle powertrain **10**, the axle drive can be made not only for the torque transfer along a transverse axis, but also for the torque transfer along a longitudinal axis. The transmission **34** or an additional transmission can, for example, be integrated into the shift transmission **20** or into a four-wheel drive transfer case.

[0039] The components of the axle drive **34** in accordance with a first embodiment will now be described with reference to FIGS. **2***a* and **2***b*. The axle drive **34** includes a transmission housing **50**, a differential unit **52** as well as brakes **54** with corresponding actuators **56**. A drive shaft **60** which is rotationally fixedly connected to the Cardan shaft **28** (FIG. **1**), for example, is rotatably journaled in the transmission housing **50**. A drive bevel gear **70** formed at an end of the drive shaft **60** is in meshed engagement with a crown gear **72**. The crown gear **72** is rotationally fixedly connected to the differential

unit **52** so that a rotary movement of the Cardan shaft **28** effects a rotary movement of the differential unit **52**. Output shafts **64** which are rotationally fixedly connected to the half-shafts **30** (FIG. **1**) are rotatably journaled in the differential unit **52** which is in turn rotatably journaled in the transmission housing **50**. The output shafts **64** rotate about an axis A.

[0040] The differential unit **52** includes a differential cage **74** and a gearset including balancing gears **76** made as bevel gears and driven gears **78**. The balancing gears **76** are driven by the rotating differential cage **74** to make an orbital movement about the axis A and are in this respect rotatably journaled in the differential cage **74** about an axis B which extends in an orthogonal direction with respect to the axis A. The balancing gears **76** mesh with the driven gears **78** which are rotationally fixedly connected to the respective output shafts **64**. In the differential unit **52**, the drive takes place via the differential cage **74** and the mutually oppositely disposed balancing gears **76** to the driven gears **78**. When driving straight ahead in normal operation, the balancing gears **76** and the driven gears **78** do not rotate relative to one another. The total differential unit **52** circulates as a block and transmits the torque uniformly to the two output shafts **64**. Only on speed differences (e.g. on cornering or asymmetrical slip ratios) between the two output shafts **64** do the two balancing gears **76** rotate oppositely in the differential cage **74** to distribute the torque generally uniformly to the two output shafts **64**.

[0041] The gearset of the differential unit **52** furthermore includes concavely arched—or also bell-shaped—coupling gears **80** and hollow shaft gears **82**. Each of the coupling gears **80** is rotationally fixedly connected to a respective balancing gear **76** and rotates with it about the axis B. The coupling gears **80** are thus also drivable by the differential cage **74** to make a respective orbiting movement about the axis A. The coupling gears **80** are arranged within the differential cage **74**. Each of the hollow shaft gears **82** surrounds a respective output shaft **64**, with the hollow shaft gears **82** being rotatably journaled inside the differential cage **74**. The coupling gears **80** are rotationally operatively connected to the hollow shaft gears **82**, with each coupling gear **80** engaging over the respective balancing gear **76** and engaging behind the respective driven gear **78**, i.e. with respect to the axis A each coupling gear **80** engages over the respective driven gear **78** in the axial direction and is simultaneously shaped radially inwardly. Each of the coupling gears **80** includes a toothed arrangement **84** which meshes with corresponding toothed arrangements **86** of the hollow shafts **82**. A transmission ratio i_1 is thus formed between each of the coupling gears **80** and the respective hollow shaft gear **82**. In a similar manner, a transmission ratio i_2 is formed between each of the balancing gears **76** and the driven gears **78**.

[0042] The number of teeth of the toothed arrangement **84** of the coupling gear **80** is preferably larger than the number of teeth of the associated toothed arrangement **86** of the hollow shaft gear **82**. In addition, the number of teeth of a toothed arrangement **95** of the respective driven gear **78** of the output shafts **64** is preferably larger than the number of teeth of an associated toothed arrangement **93** of the balancing gear **76**. Advantageous transmission ratios i_1, i_2 are thus achieved to achieve a total ratio of, for example, less than 15% for the torque transmission explained in the following.

[0043] Each of the brakes **54** includes a first disk set **90** as well as a second disk set **92**. The disks of the first disk set **90** are rotationally fixedly connected to the respective hollow shaft gear **82** and the disks of the second disk set **92** are rotationally fixedly connected to the transmission housing **50**, with the disks of the disk sets **90**, **92** engageable with one another. The disks of the disk sets **90**, **92** can be pressed toward one another for the transmission of a torque such that a braking force is transmitted between the disks of the disk sets **90**, **92** which acts to brake disks of the first disk set **90** as well as the respective hollow shaft gear **82**. Although the brakes **54** shown in FIG. **2***a* (and also in FIG. **3***a*) are made as multidisk clutches, any brake arrangements or drive arrangements can naturally be used, in particular also electric motors for the driving and/or for the generator braking, cf. FIG. **12**. In connection with the invention, wet or dry running multidisk clutches, disk brakes and disk clutches, magnetorheological clutches or electromagnetically actuated clutches are suitable as brake arrangements.

[0044] It must still be noted with respect to the embodiment in accordance with FIGS. **2***a* and **2***b* that the drive of the differential unit **52** does not generally absolutely have to take place via a driven bevel gear. In the case of use as a front axle TV unit, for example, the drive can also take place via spur gears or via a chain. An application is also provided in which the differential unit **52** is not actively driven at all. The differential unit **52** in particular also works as a torque displacement apparatus on a non-driven axle. In this case, one wheel of the vehicle receives a negative torque and the other wheel a corresponding positive torque without superimposed driving torque.

[0045] Although two coupling gears **80** with corresponding balancing gears **76** are shown in the embodiment in accordance with FIGS. **2***a* and **2***b*, the differential unit **52** can also include more or fewer coupling gears **80**. The differential unit **52** can, for example, include only one single coupling gear **80** with a corresponding balancing gear **76**. Alternatively to this, the differential unit **52** can, for example, include three coupling gears **80** with corresponding balancing gears **76**.

[0046] As shown in FIG. **2***c*, the differential unit **52** can include one or more additional balancing gears **76'** which are rotatably journaled in the differential cage **74** and which are not in meshed engagement with the coupling gears **80**. Such additional balancing gears **76'** are only in engagement with the driven gears **78** and rotate about an axis C which is perpendicular to the axis A and transverse—i.e. perpendicular or oblique—to the axis B. The vertical balancing gears **76** in FIG. **2** thus primarily serve for the TV operation (or differential locking operation) whereas the horizontal balancing gears **76'** in FIG. **2***c* only serve for the axle drive.

[0047] In the embodiment of FIG. **3***a*, unlike the embodiment in accordance with FIG. **2***a*, a hub **96** is provided which is rotationally fixedly connected to the respective hollow shaft gear **82** as well as to the disks of the first disk set **90**. By the use of the hub **96**, the ends of the output shafts **64** can be offset further inwardly. The construction space for the axle drive **34** can thus be minimized in the transverse direction. The half-shafts **30** can furthermore be correspondingly longer, with the deflection angles of the half-shafts occurring on deflection being minimized.

[0048] In the embodiment in accordance with FIG. **3***b*, the rotationally operative connection between the drive shaft **60'** and the differential unit **52** is made as a spur gear connection. In this respect, a spur gear **70'** of the drive shaft **60'** engages a spur gear **72'** which is rotationally fixedly connected to the differential unit **52**. This embodiment is suitable for a TV application in which the drive does not take place via an angle

drive (e.g. rear axle), but rather via a spur drive (e.g. front axle TV or front axle differential lock with a transverse engine arrangement). The drive thereby takes place directly at the "final drive" of the shift transmission **20**, for example. Alternatively to this, a chain is possible as a drive element.

[0049] In the following, the function of the axle drive **34** in accordance with FIGS. **2**, **3***a* and FIG. **3***b* will be explained.

[0050] A torque transmission ratio is set between the output shafts **64** by the braking of one of the hollow shaft gears **82** by means of the associated brake **54**—or also by driving the respective hollow shaft gear **82** (e.g. by means of an electrical motor, cf. FIG. **12**). If one of the hollow shaft gears **82** is braked with respect to the transmission housing **50**, the coupling gears **80**, which are driven by the rotating differential cage **74** to make an orbital movement about the axis A are namely driven to a rotation movement about the respective axis B. Accordingly, the balancing gears **76** are also driven about the axis B, with the balancing gears **76** accelerating one of the output shafts **64** and braking the other of the output shafts **64**. For example, the left hand output shaft **64** in the representation in accordance with FIG. **2***a*, FIG. **3***a* or FIG. **3***b* is accelerated and the right hand output shaft **64** is braked when the right hand hollow shaft gear **82** is braked with respect to the housing **50**.

[0051] A superimposed speed n_s on the basis of the following equation results in the event that the hollow shaft gear **82** is fully braked with respect to the housing **50**:

$$n_s = n_{AXIS} \cdot i_1 \cdot i_2$$

[0052] where n_{AXIS} is the speed of the differential cage **74** about the axis A. In the event that the right hand hollow shaft **82** is fully braked, the respective speeds n_R, n_L of the right hand and left hand output shafts **64** are calculated on the basis of the following equations:

$$n_R = n_{AXIS} - n_s$$

$$n_L = n_{AXIS} + n_s$$

[0053] In the event that the left hand hollow shaft **64** is fully braked, the respective speeds n_R, n_L of the right hand and left hand output shafts **64** are calculated on the basis of the following equations:

$$n_R = n_{AXIS} + n_s$$

$$n_L = n_{AXIS} - n_s$$

[0054] In the event that the respective brake **54** is not complete, but is operated with slip, a reduced superimposed speed n_s results and thus speeds n_R, n_L are closer to the axle speed n_{AXIS}.

[0055] The use of the concavely arched coupling gears **80** allows a small, light, simple and above all cheap differential unit **52** with a TV operation and/or a differential locking operation, which will still be explained in more detail in the following. The concavely arched coupling gear **80** in particular forms a small-volume superimposition unit in connection with the balancing gear **76** which easily has room within the construction space of the differential unit **52**. In addition, the differential unit **52** requires substantially fewer parts to provide a TV operation. The differential unit **52** is thus smaller, lighter, simpler and above all cheaper than conventional differential units which provide a TV operation.

[0056] Different embodiments of the differential unit **52** will now be explained in more detail with reference to FIGS. **4-6**, with the further components of the respective transmission being able to be made as described above in connection with FIGS. **2***a* and **3***a* for the axle drive **34** or as will still be explained in the following in connection with FIGS. **8** to **12**.

[0057] The differential unit **52***a* of FIG. **4** includes two balancing gears **76** and only one concavely arched coupling gear **80** which is rotationally fixedly connected to one of the balancing gears **76**, with the balancing gears **76** and the coupling gear **80** rotating about the axis B.

[0058] The differential unit **52***b* of FIG. **5** includes a balancing gear **76**, a connection gear **100** and a concavely arched coupling gear **80**. The balancing gear **76** is also driven here by the rotating differential cage **74** to make an orbital movement about the axis A. The connection gear **100** is in engagement with the driven gears **78** of the output shafts **64** and is rotationally fixedly connected to the coupling gear **80**. The connection gear **100** is, however, not rotatably journaled at the differential cage **74**, i.e. the connection gear **100** is not driven directly by the differential cage **74** to make an orbital movement about the axis A, but rather it only provides the application of a differential torque to the driven gears **78** by means of the coupling gear **80**. The connection gear **100** and the coupling gear **80** can also be made in one piece, which generally applies to all the variants described here.

[0059] The differential unit **52***c* of FIG. **6** includes a balancing gear **76**, a coupling gear **80** as well as an additional balancing gear **102**. The balancing gear **76** is driven by the differential cage **74** to make an orbital movement about the axis A and it meshes with the driven gears **78**. A web **104** extends from the balancing gears **76** along the axis B and is rotationally fixedly connected to the balancing gear **76** and is rotationally journaled on the oppositely disposed side in the differential cage **74**. The additional balancing gear **102** is rotatably journaled about the web **104** and is likewise in engagement with the driven gears **78**.

[0060] Each of the embodiments in accordance with FIGS. **4-6** can have an additional balancing gear or balancing gears which are in engagement with the driven gears **78** and rotate about the axis C which is perpendicular to the axis A and transverse—i.e. perpendicular or oblique—to the axis B.

[0061] FIG. **7** shows a further embodiment of the differential unit **52***d*. In this embodiment, the coupling gear **80** is rotationally fixedly connected via an intermediate shaft **101** which is rotatably journaled in the differential cage **74** to an idler gear **103** which is arranged at the inner side of the differential cage **74** at the oppositely disposed side of the differential cage. This idler gear **103** does not mesh directly with the driven gears **78**, but rather with at least one balancing gear **76** which in turn meshes with the driven gears **78**. A third balancing gear **76'** is here rotatably journaled on the intermediate shaft **101**, but can also be omitted. A particular advantage of this embodiment lies in the fact that transmission ratios smaller than 15%, for example, can be presented because the idler gear **103** can be very small.

[0062] A further embodiment of an axle drive **34***a* in accordance with the invention which enables a differential locking operation will be explained in more detail with reference to FIG. **8**.

[0063] The axle drive **34***a* includes only one single hollow shaft gear **82** as well as a multidisk clutch **110** with a corresponding actuator **112**. The multidisk clutch **110** selectively enables a rotationally fixed connection between the hollow shaft gear **82** and one of the output shafts **64** to effect a differential locking operation. The multidisk clutch **110** in particular has a clutch hub **114** which is rotationally fixedly

connected to the hollow shaft **8** gear **2** and a clutch cage **116** which is rotationally fixedly connected to the respective output shaft **64**. The disks of a first disk set **118** are rotationally fixedly connected to the clutch hub **114** and the disks of a second disk set **120** are rotationally fixedly connected to the clutch cage **120**, with the disks of the disk sets **118**, **120** engageable with one another. The disks of the disk sets **118**, **120** can be pressed toward one another for the transmission of a torque such that a torque is transmitted between the disks of the disk sets **118**, **120** to rotationally fixedly connect the clutch hub **114** and the clutch cage **116** or to set a braking torque against a relative rotation of the clutch hub **114** and the clutch cage **120**. Generally, no complete braking is required. The differential unit **52'** is locked on the connection of the hollow shaft gear **82** to the output shaft **64**; i.e. on a complete braking, the total differential unit **52'** circulates as a block and always transmits the driving torque transmitted by the drive shaft **60** uniformly to the two output shafts **64**. The transmission ratios i_1 and i_2 enable a coupling torque or reactive torque which is smaller than the locking torque. The locking torque is the torque countering the relative movement between the output shafts **64** in the differential unit **52'**. A clutch torque thus hereby results in contrast to the usual transverse lock in which the clutch torque has to amount to up to twice the locking torque which amounts, for example, approximately to the factor 0.3 of the locking torque. A much smaller multidisk clutch **110** is thus therefore required to achieve the locking effect. One of the two coupling gears **80** can selectively also be omitted here.

[0064] FIG. **9** shows an alternative example of the embodiment in accordance with FIG. **8**. The clutch cage **116'** is in particular rotationally fixedly connected to the differential cage **74**. When the disks **119**, **120** are pressed on, the hollow shaft **82** and the differential cage **74** are rotationally fixedly connected or a braking torque is set against a relative rotation of the hollow shaft **82** and the differential cage **74**. This produces a very small demand on the clutch torque, for example only 150 Nm, to achieve 1000 Nm locking torque, for example. It is generally also not necessary to brake completely in this embodiment.

[0065] Alternatively to the representation of the axle drive **34***b* in accordance with FIG. **9**, two multidisk clutches **110** can be arranged in symmetrical arrangement at both sides of the differential unit **52'**. These clutches **110** would then only have to be designed for a braking torque of, for example, 75 Nm in each case with respect to the aforesaid example.

[0066] A further embodiment of an axle drive **34***c* in accordance with the invention will be explained in more detail with reference to FIG. **10**. The axle drive **34***c* is made similar to the axle drive **34** in accordance with FIG. **3***a* and additionally includes a multidisk clutch **110'** for a differential locking operation. The multidisk clutch **54** in particular enables a TV operation and the multidisk clutch **110'** a differential locking operation. The hub **96'** of the multidisk clutch **54** simultaneously forms a clutch cage of the multidisk clutch **110'**. The disks of a first disk set **118'** of the multidisk clutch **110'** are rotationally fixedly connected to the output shaft **64'** and the disks of a second disk set **120'** are rotationally fixedly connected to the hub **96'**, with the disks of the disk sets **118'**, **120'** engageable with one another. The disks of the disk sets **118'**, **120'** can be pressed toward one another for the transmission of a torque such that a torque is transmitted between the disks of the disk sets **118'**, **120'** to brake the hollow shaft gear **82** and the output shaft **64'** with respect to one another or to connect them rotationally fixedly. Selectively, one of the two multidisk clutches **110'** for the locking operation can be omitted, i.e. only one single multidisk clutch **110'** is absolutely required.

[0067] Yet a further embodiment of an axle drive **34***d* in accordance with the invention will be explained in more detail with reference to FIGS. **11***a* and **11***b*. The axle drive **34***d* is made similar to the axle drive **34** in accordance with FIG. **2**, but includes an alternative clutch arrangement **130** with a corresponding actuator **131**. The clutch arrangement **130** has a clutch cage **132**, a switchable clutch hub **134** as well as first and second disk sets **136**, **138**. The disks of the first disk set **136** are rotationally fixedly connected to the clutch hub **134**. The disks of the second disk set **138** are rotationally fixedly connected to the clutch cage **132**.

[0068] The clutch cage **132** is rotationally fixedly connected to the hollow shaft gear **82**. The clutch hub **134** is switchable between a first and a second position. In the first position shown in FIG. **11***a*, the clutch hub **134** is rotationally fixedly connected to the transmission housing **50** via toothed arrangements **140** to enable the TV operation. In particular, upon actuation of the multidisk clutch **130**, the hollow shaft gear **82** is braked with respect to the transmission housing **50** to drive the coupling gear **80** about the axis B and thus to carry out the TV operation. In the second position shown in FIG. **11***b*, the clutch hub **134** is rotationally fixedly connected to the output shaft **64"** via toothed arrangements **142** to enable the differential locking operation. In particular, upon actuation of the multidisk clutch **130**, the hollow shaft gear **82** is rotationally fixedly connected to the output shaft **64"** to carry out the differential locking operation. The axle drive **34***d* of FIGS. **11***a* and **11***b* only requires one multidisk clutch **130** and one actuator **131** per respective side to provide a TV operation and a differential locking operation. The axle drive **34***c* is thus smaller, lighter, simpler and cheaper.

[0069] A further embodiment of an axle drive **34***e* is shown in FIG. **12**. The axle drive **34***e* in accordance with FIG. **12** includes the same components as the axle drive **34** in accordance with FIG. **2***a*, but the brakes **54** are omitted. Instead, the axle drive **34***e* includes electric motors **150**, with each of the electric motors **150** having a stator **152** and a rotor **154**. The stator **152** is fixedly connected to the housing **50** and the rotor **154** is rotationally fixedly connected to the hub **96** or to the hollow shaft **82**. The electric motors **150** can each be operated as a motor—that is driving—or as a generator—that is braking. The introduction of positive and negative superimposed torques is thereby possible for a TV operation. The two electric motors **150** can be synchronized for a locking operation.

[0070] Deviating from the representation in accordance with FIG. **12**, the electric motors **150** can also be provided with transmission gears (e.g. planetary gears) which step down the respective engine speed. High-speed engines **150** can thereby be used.

REFERENCE NUMERAL LIST

[0071] **10** vehicle powertrain
[0072] **12** drive
[0073] **16** power transmission path
[0074] **18** motor
[0075] **20** transmission
[0076] **28** Cardan shaft
[0077] **30** half-shaft
[0078] **32** wheel
[0079] **34**, **34***a*, **34***b* axle drive
[0080] **34***c*, **34***d*, **34***e*

[0081] **40** control unit
[0082] **42** yaw rate sensor
[0083] **44** wheel speed sensor
[0084] **50** differential housing
[0085] **52**, **521** **52***a*, differential unit
[0086] **52***b*, **52***c*, **52***d*
[0087] **54** brake
[0088] **56** actuator
[0089] **60**, **601'** drive shaft
[0090] **64**, **64'**, **64"** output shaft
[0091] **70** drive bevel gear
[0092] **70'** driven gears
[0093] **72** crown gear
[0094] **72'** spur gear
[0095] **74** differential cage
[0096] **76**, **76'** balancing gear
[0097] **78** driven gear
[0098] **80** coupling gear
[0099] **82** hollow shaft gear
[0100] **84**, **86** toothed arrangement
[0101] **90**, **92** disk set
[0102] **93**, **95** toothed arrangement
[0103] **96**, **961** hub
[0104] **100** connection gear
[0105] **101** intermediate shaft
[0106] **102** additional balancing gear
[0107] **103** idler gear
[0108] **104** web
[0109] **110**, **110'** multidisk clutch
[0110] **112**, **112'** actuator
[0111] **114** clutch hub
[0112] **116** clutch cage
[0113] **118**, **118'**, **119** disk set
[0114] **120**, **120'** disk set
[0115] **130** multidisk clutch
[0116] **131** actuator
[0117] **132** clutch cage
[0118] **134** clutch hub
[0119] **136**, **138** disk set
[0120] **140**, **142** toothed arrangement
[0121] **150** electric motor/generator
[0122] **152** stator
[0123] **154** rotor

1. A transmission comprising a rotatable differential cage, two output shafts each driving a corresponding one of two driven gears, a balancing gear which is drive-operatively coupled to the driven gears and rotatably journaled at the differential cage, a hollow shaft surrounding one of the output shafts, and a coupling gear which is drive-operatively coupled, on the one hand, to at least one of the driven gears and, on the other hand, to the hollow shaft and with the hollow shaft being able to be braked and/or driven relative to a part of the transmission.

2. The transmission in accordance with claim **1**, wherein the balancing gear and the coupling gear are made in one part.

3. The transmission in accordance with claim **1**, wherein the balancing gear and the coupling gear are made in two parts, with the balancing gear and the coupling gear being rotationally fixedly connected to one another.

4. The transmission in accordance with claim **1**, further including a second balancing gear which is drive-operatively coupled to the driven gears of the output shafts and a second coupling gear which is drive-operatively coupled, on the one hand, to the second balancing gear and, on the other hand, to the hollow shaft.

5. The transmission in accordance with claim **1**, further including a second hollow shaft which surrounds the other of the output shafts and which is drive-operatively coupled to the coupling gear, with one of the hollow shafts being selectively braked or driven to set the torque transmission ratio between the output shafts.

6. The transmission in accordance with claim **1**, further including a brake, a clutch or an electric motor or electric generator for the braking or driving of the hollow shaft.

7. The transmission in accordance with claim, wherein the coupling gear is driven by the differential cage to make an orbital movement about a rotational axis of the output shafts.

8. The transmission in accordance with claim **1**, wherein the coupling gear is rotatable about an axis which extends in a transverse direction with respect to a rotational axis of the output shafts.

9. The transmission in accordance with claim **1**, wherein the coupling gear is drive operatively connected to the driven gears of the output shafts via the balancing gear or a connection gear.

10. The transmission in accordance with claim **1**, wherein the coupling gear engages the hollow shaft behind the driven gears within the differential cage.

11. The transmission in accordance with claim **1**, wherein the coupling gear is arranged within the differential cage.

12. The transmission in accordance with claim **1**, wherein a portion of the hollow shaft is arranged within the differential cage.

13. The transmission in accordance with claim **1**, further including a transmission housing with respect to which the hollow shaft can be braked or driven.

14. The transmission in accordance with claim **1**, wherein the hollow shaft can be braked or driven relative to the associated output shaft or relative to the differential cage.

15. The transmission (**34**) in accordance with claim **1**, wherein a toothed arrangement of the coupling gear meshes with a toothed arrangement of the hollow shaft.

16. The transmission in accordance with claim **15**, wherein the toothed arrangement of the hollow shaft is arranged within the differential cage.

17. The transmission in accordance with claim **15**, wherein the number of teeth of the toothed arrangement of the coupling gear is larger than the number of teeth of the associated toothed arrangement of the hollow shaft.

18. (canceled)

19. The transmission in accordance with claim **1**, wherein the coupling gear is rotationally fixedly connected to an idler gear via an intermediate shaft, with the idler gear meshing with the balancing gear which in turn meshes with the driven gears.

20-22. (canceled)

23. A transmission, comprising:

an input shaft;

first and second output shafts;

a differential unit having a differential cage rotatably supported in a housing and driven by said input shaft, and a gearset disposed within said differential cage, said gearset including a first driven gear fixed for rotation with said first output shaft, a second driven gear fixed for rotation with said second output shaft, a first balancing gear meshed with said first and second driven gears, a

first coupling gear fixed for rotation with said balancing gear, and a first transfer gear meshed with said first coupling gear and configured to surround said first output shaft; and

a coupling unit for selectively limiting rotation of said first transfer gear relative to one of said housing, said first output shaft and said differential cage.

24. The transmission of claim **23** wherein said coupling unit is a brake that can be selectively actuated by a control system for inhibiting rotation of said first transfer gear relative to said housing.

25. The transmission of claim **23** wherein said coupling unit is a brake that can be selectively actuated by a control system for limiting relative rotation between said first transfer gear and one of said first output shaft and said differential cage.

26. The transmission of claim **23** wherein said coupling unit is a drive motor that can be selectively actuated by a control system for varying the rotational speed of said first transfer gear.

27. The transmission of claim **23** wherein said gearset further includes a second balancing gear meshed with said first and second driven gears, and a second transfer gear surrounding said second output shaft and meshed with said first coupling gear, and wherein said transmission further includes a second coupling unit for selectively limiting rotation of said second transfer gear relative to one of said housing, said second output shaft and said differential cage.

28. The transmission of claim **27** wherein said gearset further includes a second coupling gear fixed for rotation with said second balancing gear and meshed with both of said first and second transfer gears.

29. The transmission of claim **28** wherein said first and second balancing gears are rotatably supported by said differential cage.

30. The transmission of claim **28** wherein each of said first and second coupling gears is disposed between said differential cage and corresponding ones of said first and second balancing gears and is configured to generally surround said first and second driven gears, and wherein each of said first and second coupling gears has gear teeth formed at its edge that are meshed with gear teeth formed on each of said first and second transfer gears.

31. The transmission of claim **27** wherein said first and second balancing gears are rotatably supported by said differential cage.

32. The transmission of claim **27** wherein only said second balancing gear is rotatably supported by said differential cage.

33. The transmission of claim **23** wherein said first coupling gear is disposed between said differential cage and said first balancing gear and is configured to generally surround a first portion of said first and second driven gears, and wherein said first coupling gear has gear teeth formed at its edge that mesh with gear teeth on said first transfer gear.

34. The transmission of claim **33** wherein said gearset further includes a second balancing gear meshed with said first and second driven gears, and a second coupling gear fixed for rotation with said second balancing gear, wherein said second coupling gear is disposed between said differential cage and said second balancing gear and is configured to generally surround a second portion of said first and second driven gears, and wherein said second coupling gear has gear teeth formed at its edge that mesh with said gear teeth on said first transfer gear.

35. The transmission of claim **32** wherein said gearset further includes a second transfer gear surrounding said second output shaft and which has gear teeth meshed with gear teeth on both of said first and second coupling gears, and wherein said transmission further comprising a second coupling unit for selectively limiting rotation of said second transfer gear relative to one of said housing, said second output shaft and said differential cage.

36. The transmission of claim **23** wherein said coupling unit includes a first clutch selectively operable to inhibit relative rotation between said first transfer gear and said housing, and a second clutch selectively operable to inhibit relative rotation between said first transfer gear and said first output shaft.

37. The transmission of claim **23** wherein said coupling mechanism is operable in a first condition to limit relative rotation between said first transfer gear and said housing and in a second condition to limit relative rotation between said first transfer gear and said first output shaft.

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